

11-14 November 2025
Opatija, Croatia



Contribution ID: 29

Type: talk

Groundwater modelling for the EMR region Einstein Telescope facility: Geological and hydro(geo)logical refinements to resolve surface drawdown and tunnel inflows using FEFLOW models

Comprehensive hydrogeological and groundwater modelling studies are underway to assess feasibility of the construction of the Einstein Telescope (ET) facility in the Euregion Meuse-Rhine (EMR) region. The facility includes ~30 km tunnels with 10 m of width arranged in a triangular shape, and shafts and cavern structures in the corners. The construction and operation of this facility will require dewatering altering groundwater flow in the surrounding and shallow aquifers, where groundwater level drawdowns and baseflow loss are expected.

To understand the impacts of this proposed facility on drawdown and baseflow, we develop and refine geological and hydrogeological understanding through models. Using these models, we improve existing predictions and support the design of the facility and mitigation of hydro-environmental impacts.

The geology of the EMR region is complex; characterized by a highly fractured rock geology, faulted subsurface, and changing stratigraphy across the proposed tunnel site. For that reason, the geological model has been updated with new drilling data and packer tests. From the gathered data, the software Leapfrog have been selected to build a complex regional geological model to represent the geological context as well as to be refined with new borehole data in order be as accurate as possible and export this data to a groundwater flow simulation software.

To numerically evaluate this situation, we used FEFLOW to build groundwater models based on the Leapfrog model data. We represent fractures and conductivity based on hydrogeological units, and the most recent tunnel location and cavern geometry. To generate our models, we emphasize local refinement of geology and hydraulic conductivity around the triangle corners in order to assess drawdowns and tunnel drainage accurately. At the tunnel boundary, we consider a 1st type pressure boundary condition (set to atmospheric pressure) and flow is inhibited by the conductivity of the grouting layer. Tunnel engineers for the site suggest an inflow of 10L/100m/min at the tunnels and 50L/100m/min at the caverns. Previous models have calculated acceptable scenarios based on grouting conductivities ranging between $5 \cdot 10^{-10}$ m/s (3800m³/d total drainage) and $1 \cdot 10^{-10}$ m/s (776 m³/d). *Conceptual geological and parameter permeability uncertainty is included in the analysis of results. Hydraulic conductivity geometric mean values obtained from at the different boreholes from packer tests range from $6.010 \cdot 10^{-6}$ m/s to $3.1 \cdot 10^{-9}$ m/s and expected grouting conductivity in the tunnels range from $1.0 \cdot 10^{-9}$ to $1.0 \cdot 10^{-10}$ m/s.*

Overall, and considering previous models and new updated data, results are consistent and our work demonstrate how modelling tools like FEFLOW can provide estimations and solutions for drawdowns expected because of the tunnel. Information generated from this task will inform the ET project bid and mitigation strategies such as grouting, water reuse or management aquifer recharge (MAR) solutions.

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Session Classification: Site Preparation & Characterization (SCB)

Track Classification: SCB: SCB